REVIEW

Quantifying the risk of sports injury: a systematic review of activity-specific rates for children under 16 years of age

Anneliese B Spinks, Roderick J McClure

Br J Sports Med 2007;**41**:548–557. doi: 10.1136/bjsm.2006.033605

Injuries caused by sports and other forms of physical activity in young children constitute a significant public health burden. It is important to quantify this risk to ensure that the benefits of sport participation are not outweighed by the potential harms. This review summarises the literature reporting exposure-based injury rates for various forms of physical activity in children aged 15 years and younger. Forty eight studies were found, of which 27 reported injury rates per hourly based exposure measured and 21 reported injury rates according to some other measure. Fourteen different sports and activities were covered, mostly team ball sports, with soccer being the most widely studied. Injury definition and the method of ascertaining and measuring injuries differed between studies, which created a large variation in reported injury rates that did not necessarily represent actual differences in injury risk between activities. The highest hourly based injury rates were reported for ice hockey, and the lowest were for soccer, although the range of injury rates for both of these activities was wide. Very few studies have investigated sports-related injuries in children younger than 8 years or in unorganised sports situations.

The proportion of injury that is related to sport and recreation activities reported in geographically, culturally and climatically diverse countries clearly establishes sport and recreation participation as a leading cause of the paediatric injury burden.[1] For example, epidemiological studies conducted in emergency departments and hospitals in Australia,[2 3] Norway,[4 5] New Zealand[6] and France[7] have reported that sport and recreational injuries account for 15–20% of injury presentations, and an injury surveillance system in Swansea, Wales reported that 36% of children's fractures were due to sport and leisure activities.[8]

However, although the contribution of sport and recreation to the overall burden of injury is well documented, most studies have not quantified the incidence of sport and recreational injury in terms of exposure to risk. The studies that have quantified exposure-specific risks of injury are few and largely focused on a limited number of types of sport. No systematic reviews have been conducted that collate information from across the literature and synthesise the information to facilitate translation of the science to public health benefit. A summary of the available exposure-based injury risk estimates is essential to compare the injury risk for different types of activities across population distributions, and to support calculations of the balance of potential benefit versus harm for various activities.[9]

This subject is critical given recent efforts to encourage greater participation in physical activity by children to combat the growing obesity epidemic.[10 11] A responsible public health policy requires that the potential risks as well as the benefits of increased physical activity through sports participation be quantified. Increased knowledge about the injury harms associated with specific physical activity exposures is an important part of an overall risk management strategy.

The aim of this systematic review was to summarise the literature reporting exposure-based injury rates for various forms of physical activity in children younger than 16 years of age.

METHOD

Inclusion criteria

Studies were included in the review if they reported injury rates in relation to a measure of exposure to a type of physical activity for children in the age range 5–15 years. The types of activities covered included both sports and individual activities such as athletics, martial arts and bicycle riding. However, studies on playground or general school time injuries were not included in the review. Studies were included if they measured either organised (community or school) or unorganised activity. Both prospective and retrospective studies were included, but the results are summarised separately.

The measures of exposure included were primarily hours of activity participation, but studies that used other exposure denominators such as athlete exposures, participant seasons, balls bowled and ''player plays'' were also included. Studies were excluded if they did not provide an objectively measured exposure denominator enabling the quantification of meaningful injury rates. Studies were also excluded if it was not possible to calculate injury rates for children exclusively in the 5–15 year age range. Hence, studies that included older children or adults were excluded if they did not report age breakdowns of injury occurrence and sample size.

Search strategy

A number of techniques were used to locate relevant studies for the review. These included electronic database searches (Ovid Medline, CINAHL, EMBASE), searching international government and university websites for published reports, scanning reference lists of relevant publications, and hand searching selected scientific journals

See end of article for authors' affiliations

Correspondence to: A Spinks, School of Medicine, Griffith University, University Drive, Meadowbrook, Queensland 4131, Australia; a.spinks@griffith.edu.au

Accepted 13 March 2007
Published Online First 1 May 2007

including the *American Journal of Sports Medicine, British Journal of Sports Medicine, International Journal of Sports Medicine, Journal of Science and Medicine in Sport, Pediatrics* and *Injury Prevention*.

Data extraction

For each included study, all available information on the sample population (age, gender, source), injury definition, method of injury ascertainment and measurement was extracted. Injury rates per the nominated measure of exposure with 95% CI were also extracted for children aged 5–15 years. For some studies, both injury rates and 95% CI were provided, but for others these were calculated from information provided in the text, tables or graphs. For a limited number of studies, there was insufficient information available to calculate CIs.

Some studies provided information that allowed the breakdown of injury rates into gender, age, play mode (game or practice) and injury severity categories.

DESCRIPTION OF STUDIES

The literature search revealed a large number of studies on the topic of childhood injury and physical activity, but the vast majority of published articles were case series reports which did not define the population at risk and were limited to analysis of those who sought treatment only.

Forty eight studies that met the inclusion criteria were located. Twenty seven of them had prospective study designs and reported injury rates per hours of player exposure to the sport or activity. Table 1includes the description of these studies. The remaining 21 studies which reported injury rates in relation to some other exposure measure are described in table 2. The latter is divided into two sections: prospective (n = 14) and retrospective (n = 7) study designs.

Tables 1 and 2 display information for each study on the location, activity studied, sample size (or other size measure, eg, player hours), population characteristics, injury definition and method of data measurement. In table 1, injury rates are expressed per 1000 hours of player exposure, and in table 2, they are displayed according to the relevant exposure measure.

The included studies reported injury rates for 14 different activities: soccer (indoor and outdoor, 20 studies), ice hockey (nine studies), baseball/softball (six studies), American football (six studies), rugby (league and union, six studies), basketball (two studies), handball (two studies) and Australian Rules Football (AFL), netball, volleyball, bandy, bicycle riding, judo and karate (one study each).

Injury definitions

A wide range of injury definitions was used by the included studies, mostly dependent on time lost from activity participation or the necessity for medical treatment. Other injury definitions were limited to a particular type or body region of injury including upper extremity injuries,[59] facial injuries[58] and elbow injuries.[54]

Injury definitions had a big effect on the resulting injury incidence, mainly because of the differing threshold of severity necessary to constitute an injury event. The most inclusive definition of injury encompassed minor discomfort that did not restrict further play,[30] and the most restrictive required a minimum of 7 days absence from the sport.[41]

Injury ascertainment and measurement

The studies used various methods to identify and record details of injury episodes including direct observation of matches by trained study personnel (five studies), injury surveillance implemented either in the general community or during sporting tournaments (11 studies), reporting by team coaches or other school or team personnel (26 studies), self or parent report (12 studies), and retrospective analysis of medical insurance claims (six studies). Nearly a quarter of the studies combined two[12 16 18 20 21 33 34 36 39 41] or three[40] of these methods to identify injury cases.

Once injuries were ascertained, the relevant information was obtained, normally by a combination of methods including direct examination or interview with the injured player or a parent or from data recorded by either the team coach or other team personnel, injury surveillance staff, a treating specialist or doctor or on medical insurance claims.

METHODOLOGICAL QUALITY ASSESSMENT OF INCLUDED STUDIES

The most salient methodological limitations associated with the included studies were those related to the injury capture processes, and direct observation was used in only five of the studies. This was particularly a problem when the technique did not guarantee that all incidents that complied with the injury definition would be identified. For example, de Loes and Goldie[15] used a definition for injury that required limitations to further participation, but injuries were identified by an injury surveillance system implemented by medical treatment facilities within the community. It is possible that participants may have sustained an injury that met the definition criteria, but did not seek professional treatment. These cases would therefore have been missed by the surveillance system.

Failure to identify all injury cases was possible even when the method used to capture cases was more coherent with the injury definition. Team coaches or parents may under-report injury occurrence, and insurance claims data may similarly be incomplete. To minimise the loss of potential injuries, some studies used more than one method for capturing data. Examples of this included cross-checking reports from team personnel against emergency department records,[12] direct observation of randomly selected games, as well as reliance on coach reports[40] and the collection of reports from both team coaches and parents of players.[21 41]

Methodological quality of the included studies was also affected by limited reporting. Only seven of studies included 95% CIs along with injury rates,[18–20 27 45 47 56] although most studies provided sufficient information for their calculation to be possible. They could not be calculated for five studies because of a lack of either sample size or injury incidence reporting.[28 34 38 53 55] Information was also generally lacking with regard to drop-outs and compliance with the study protocol.

Additional limitations were that the study populations were generally convenient samples with no random selection of participants, and exposure was mostly estimated collectively rather than on an individual basis.

RESULTS

Injury risk per exposure hours

Twenty seven studies reported injuries per hours of exposure. Risk per 1000 h for various sports ranged from 0.04 to 127.3. The highest injury risk was recorded for ice hockey, and the lowest was for soccer, although wide variations occurred between studies reporting the risk of soccer injuries. These variations in injury risk spanned a difference of over 1000-fold (ranging from 0.04 to 75.8 per 1000 h) depending on the threshold of injury definition, age of players, and type of soccer (indoor vs outdoor). CIs were very wide for two studies,[12 25] but generally indicated the estimated injury rate to be reasonably close to the reported result.

Injury risk related to other measures of exposure

Other measures of exposure included per participant season (11 studies), per game or practice (six studies), per participant per year (three studies), per participant lifetime (two studies), per balls pitched (for baseball, one study), and per player plays (for

Table 1 Studies quantifying the risk of activity-related injury in children aged 15 years and under: injuries per exposure hours

Study (first author, year and location)	Sport/activity	Study design and duration	Participant population	Injury definition and method of measurement	Results: injuries per 1000 h (95% CI)
Andren-Sandberg, 1982, Lund, Sweden[12]	Handball	Prospective cohort; 3-day annual tournament over 3 years	All competitors in Lundaspelen junior league tournament (n = 7320)	Definition: all injuries. Measurement: questionnaire completed by person responsible for team 2 weeks after tournament. Cases checked with tournament doctor and emergency department records	Boys: <11 years, 26 (6 to 131); 11–12 years, 30 (9 to 102); 13–14 years, 41 (15 to 114). Girls: <11 years, 31 (7 to 153); 11–12 years, 41 (13 to 137); 13–14 years, 26 (8 to 88)
Backous, 1988, Washington, USA[13]	Soccer	Prospective cohort; 5 weeks	Participants aged 6–17 years in five 1-week soccer camps (681 boys, 458 girls)	Definition: any soccer-related medical problem causing the player to miss full participation in one or more sessions of competition or instruction. Measurement: all injuries observed and recorded by a single trainer certified by the National Athletic Trainers' Association	Boys, 6.1 (5.0 to 7.6). Girls, 7.0 (5.5 to 9.0)
Davidson, 1987, Australia[14]	Rugby union	Prospective; 18 years	All competitors participating in interschool rugby matches at one private school	Definition: all injuries presenting to a casualty station operating on-site during Saturday interschool matches. Measurement: a documentation system recorded details of all treated injuries	<13 years, 13.6 (11.4 to 16.3); 14–15 years, 18.4 (15.6 to 21.6)
de Loes, 1988, Skaraborg County, Sweden[15]	Soccer	Prospective cohort; 1 year	All members of the municipal population (n = 31620)	Definition: any incident causing absence from further sporting participation. Measurement: an injury surveillance system registered all visits to medical clinics in the municipality. All injured persons were contacted for a telephone interview. Exposure data were collected via a questionnaire sent to 7% of the population, sports clubs data and information from school PE classes	Boys: 8–10 years, 0.04 (0.01 to 0.15); 11–12 years, 0.10 (0.03 to 0.29); 13–14 years, 0.19 (0.08 to 0.48). Girls: 8–10 years, 0.14 (0.03 to 0.77); 10–12 years, 0.47 (0.22 to 1.02); 13–14 years, 0.38 (0.25 to 0.97)
Durie, 2000, Christchurch, New Zealand[16]	Rugby	Prospective cohort; one season	Competitors in schoolboy rugby (n = 442)	Definition: all players injured during game; minor, player played again within 7 days; moderate, unable to play 1–3 weeks; severe, unable to play >3 weeks. Measurement: team managers recorded all injuries; injured players were assessed by an investigator; insurance claims were also cross-checked	All injuries: under 13, 20.0 (11.3 to 35.5); under 14, 20.8 (15.0 to 28.8); under 15, 25.0 (17.6 to 35.5); under 16, 26.9 (19.0 to 38.2). Moderate and severe injuries: under 13, 3.6 (1.1 to 13.1); under 14, 4.2 (2.1 to 8.6); under15, 7.6 (4.0 to 14.2); under 16, 7.8 (4.0 to 15.3)
Elias, 2001, USA[17]	Soccer	Prospective cohort; 10 years	Participants aged 9–19 years in the USA cup, an annual youth soccer tournament	Definition: all incidents treated by the USA cup medical facility. Measurement: information on all patients presenting to the tournament medical facility was collected using a paper encounter form	Boys: <12 years, 11.22 (10.58 to 13.20); <14 years, 11.81 (10.89 to 12.79); <16 years, 16.05 (14.99 to 17.19). Girls: <12 years, 12.64 (11.03 to 14.48); <14 years, 16.92 (15.48 to 18.49); <16 years, 17.68 (16.25 to 19.24)
Emery, 2006, Calgary, Canada[18]	Soccer (indoor and outdoor)	Prospective cohort; one season	Participants competing in indoor (n = 142) and outdoor (n = 317) soccer teams	Definition: any soccer injury that resulted in the inability to complete a full session, or miss a subsequent sport session, and/or required medical attention. Measurement: each injured player or a team designate completed an injury report form; email or telephone contact was maintained fortnightly to capture missing data	Indoor soccer: 4.45, (3.10 to 6.19). Outdoor soccer: 5.59 (4.42 to 6.97)
Emery, 2006, Calgary, Canada[19]	Ice hockey	Prospective cohort, one season	Participants aged 9–16 years registered with the Calgary Minor Hockey Association (n = 986)	Definition: any injury that required medical attention, resulted in cessation from participation in either session that injury occurred or subsequent session. Measurement: injury surveillance system organised to monitor all injuries; included 5 data collection instruments: weekly participant exposure sheet, individual injury report form, therapist injury assessment form, physician diagnosis/treatment plan form and preseason medical form	9–10 years, 1.12 (0.61 to 1.87); 11–12 years, 3.32 (2.49 to 4.34); 13–14 years, 4.16 (3.26 to 5.23)
Garraway, 1995, Scotland[20]	Rugby union	Prospective cohort; one season	Members of 26 Scottish Rugby Union affiliated clubs in the South of Scotland (n = 204 aged <16 years)	Definition: any injury that prevented the player from training or playing rugby for the remainder of the game in which the injury was sustained. Measurement: one 'linkman' from each club recorded all injury events; weekly visits ensured all details were completed; players were also contacted mid-season and at the end of the season to ensure completeness of registered injuries	<16 years, 3.41 (2.28 to 5.11)
Hoff, 1986, Kansas city, USA[21]	Soccer (indoor and outdoor)	Prospective cohort; one season	Participants aged under 16 years in Western Missouri Soccer League and Miracle Sports Complex (outdoor, n = 455, indoor, n = 366)	Definition: any medical problem that occurred in practice or play that caused player to miss all or part of game or practice or which limited player ability. Measurement: self-addressed prepaid envelopes and questionnaires were sent to all parents seeking information on all injuries; coaches were also surveyed about injuries on their teams and information about practice and warm-up	Outdoor soccer: <8 years, 4.4 (1.8 to 1.12); 8–9 years, 4.5 (2.1 to 9.8); 10–11 years, 2.6 (1.1 to 6.6); 12–13 years, 9.1 (5.6 to 14.7); 14–15 years, 6.0 (2.2 to 15.8). Indoor soccer: <8 years, 11.1 (2.7 to 59.7); 8–9 years, 13.0 (4.7 to 37.3); 10–11 years, 46.8 (29.9 to 72.7); 12–13 years, 37.8 (23.5 to 60.6); 14–15 years, 75.8 (54.3 to 103.7)

Table 1 Continued

Study (first author, year and location)	Sport/activity	Study design and duration	Participant population	Injury definition and method of measurement	Results: injuries per 1000 h (95% CI)
Inklaar, 1996, Netherlands[22]	Soccer	Prospective cohort; half season	Male competitors participating in two non-professionals sporting clubs	Definition: any injury that resulted in a reduction in the amount of soccer activity, the need for advice or treatment or adverse social or economic effects. Measurement: players reported injuries each week to a contact person (usually coach or team leader) delegated to the team; additional information was sought from therapists if necessary	13–14 years, 12.8 (6.7 to 25.4)
Kakavelikas, 2003, Greece[23]	Soccer	Prospective cohort; one year	Competitors aged 12–15 years in 24 Greek soccer clubs (n = 287)	Definition: any condition that limits athletic participation for at least the day after the day of onset. Measurement: injured players were examined by a specialist, and a standardised rating form recorded all relevant injury data; team coaches registered all injuries with the study; telephone contact with specialists occurred if more details were required.	Total, 4.0 (3.5 to 4.6); games, 5.6 (4.6 to 6.8); practice, 3.3 (2.7 to 4.0)
Le Gall, 2006, France[24]	Soccer	Prospective cohort; 10 seasons	Competitors aged 13–15 years in the French National Institute of Football	Definition: any injuries received during game or practice that prevented the player from participating in game or practice for at least 48 h, not including the day of injury. Measurement: all injuries were recorded by a single physician based at the football centre for the study duration	<14 years, 4.9 (4.5 to 5.4); <15 years, 4.6 (4.2 to 5.1); <16 years, 5.2 (4.7 to 5.8); total, 4.8 (4.5 to 5.1); games, 11.2 (10.1 to 12.4); practice, 3.9 (3.6 to 4.2)
Lindenfeld, 1994, USA[25]	Indoor soccer	Prospective observation; 7 weeks	Competitors of all ages at an indoor soccer arena	Definition: incident causing player to leave field, play to be stopped by referee or request for medical attention. Measurement: study representative observed each game and examined each injury. A questionnaire was completed with each injured player	Boys: <12 years, 28 (6.6 to 141.6); 12–15 years, 44 (20.9 to 93.5). Girls: <12 years, 56 (20.2 to 151.2); 12–15 years, 63 (25.9 to 152.4)
Maehlum, 1986, Norway[26]	Soccer	Prospective cohort; one soccer tournament	Competitors aged under 18 years in the Norway Cup Soccer Tournament (1016 boy's teams, 322 girl's teams)	Definition: all incidents and hyperventilations treated in field hospitals or on field. Measurement: all injuries requiring treatment were recorded on specific forms by assigned staff members	Boys: <12 years, 9.3 (6.9 to 12.7); 12–13 years, 9.1 (7.2 to 11.6). Girls: 12–13 years, 13.0 (8.9 to 19.2)
McMahon, 1993, Melbourne, Australia[27]	Australian rules Football and Vickick (a modified version for players aged under 10 years)	Prospective cohort; one season	Competitors in a random sample of 18 under 15 teams, 18 under 10 teams and 18 Vickick clinics	Definition: any trauma that caused some disability or pain; injuries classified into those requiring health service use and those causing functional impairment. Measurement: a volunteer coordinator for each club or clinic maintained exposure data and completed injury report forms for each injured player	All injuries: Vickick, 3.49 (2.0–5.0); <10 years, 8.29 (6.5–10.1); <15 years, 9.79 (8.2–11.4). Functional impairment: Vickick, 1.49 (0.7–2.8); <10 years, 4.89 (3.5–6.3); <15 years, 7.32 (6.0–8.7). Health service use: Vickick, 0.33 (0.1–0.8); <10 years, 0.64 (0.2–1.4); <15 years, 3.93 (2.9–4.9)
Nilsson, 1978, Oslo, Norway[28]	Soccer	Prospective cohort; one soccer tournament	Competitors participating in the Norway Cup	Definition: any injury occurring during participation in the soccer tournament which resulted in first aid treatment being sought at a first-aid tent; reported injuries excluded blisters and minor skin abrasions. Measurement: all relevant injury details were recorded at the first aid stations	Boys*: 11–12 years, 12; 13–14 years, 15
Pasternack, 1996, Rochester, NY, USA[29]	Baseball	Prospective cohort; one season	Competitors aged 7–18 years participating in two Little League Baseball organisations	Definition: all ball-related injuries in players aged 7–8 years and ball-related facial injuries in players aged 9–12 years that resulted in a missed game, evaluation by a physician or dentist, or inability to play a certain position. Measurement: the manager of each team completed an survey form for each injury	7–8 years, 0.13 (0.05 to 0.39); 9–12 years, 0.12 (0.06 to 0.24)
Pringle, 1998, Auckland, New Zealand[30]	Rugby union, rugby league, netball	Observational cross-section; 4-week period (258 games)	Competitors aged 6–15 years in organised competition at 15 venues (1932 rugby union, 1730 rugby league, 1512 netball)	Definition: minor, discomfort after game but able to play following week; moderate, prevented participation in following weeks. Measurement: trained observers completed incidence sheet plus an interview with player after game; a telephone interview followed within 3 days after incident; follow-up occurred 1 week later to determine if player could compete in game	All injuries: rugby union, 15.5 (10.5 to 23.0); rugby league, 24.5 (17.8 to 33.7); netball, 13.0 (7.9 to 21.3). Moderate injuries: rugby union, 0.6 (0.2 to 3.6); rugby league, 9.5 (5.7 to 15.9); netball, 6.1 (3.0 to 12.5)
Roberts, 1999, Minnesota, USA[31]	Ice hockey	Prospective cohort	Competitors aged 11–19 years in five community-sponsored ice hockey tournaments (695 boys, 112 girls)	Definition: any disability evaluated by the tournament trainer or on-site doctor; significant, causing cessation of participation the day after injury, any dental injury requiring professional attention, any injury to the head or face, or any injury requiring substantive professional attention. Measurement: all injuries were recorded by a certified athletic trainer at the time of evaluation	All injuries: boys: 12–13 years, 127.3 (72.5 to 212.7); 14–15 years, 85.5 (44.2 to 159.2); girls: 12–15 years, 50.5 (20.6 to 123.1). Significant injuries: boys: 12–13 years, 57.9 (25.7 to 129.0); 14–15 years, 42.7 (17.3 to 104.3)
Schmidt-Olsen, 1985, Denmark[32]	Soccer	Prospective cohort; 5-day tournament consisting of 945 matches (821.5 h)	Competitors aged 9–19 years competing in a soccer tournament (n = 6600)	Definition: any incident treated at tournament first aid stations; slight, minor first-aid, no advice to reduce activity; moderate, medical care but not hospitalisation, advice to reduce activity; severe, requires hospital treatment. Measurement: all treated injuries recorded by assigned staff	All injuries: boys: 9–11 years, 7.9 (3.7 to 17.1); 12–13 years, 9.9 (6.6 to 14.9); girls: 9–13 years, 0.92 (0.53 to 1.60). Moderate and severe injuries: boys: 9–11 years, 2.6 (0.94 to 7.6); 12–13 years, 4.0 (2.4 to 6.6); girls: 9–13 years, 0.52 (0.26 to 1.07)

Table 1 Continued

Study (first author, year and location)	Sport/activity	Study design and duration	Participant population	Injury definition and method of measurement	Results: injuries per 1000 h (95% CI)
Schmidt-Olsen, 1991, Denmark[33]	Soccer	Prospective cohort; one year	Male competitors aged 12–18 years in 3 large soccer clubs (n = 496)	Definition: any injury that handicapped the player during game or required special treatment to continue play or prevented further participation. Measurement: all injuries were registered by team coaches or injured players	12–13 years, 3.4 (2.0 to 7.2); 14–15 years, 3.8 (2.5 to 7.6)
Soderman, 2001, Umea, Sweden[34]	Soccer	Prospective cohort; one season	Female competitors aged 14–20 years	Definition: a condition that made a player unable to participate fully in games or practice sessions. Measurement: all injuries were recorded and reported by the players in cooperation with the team coaches or trainers; regular contact was maintained by study personnel with players and team coaches	14 years, 5.1*; 15 years, 7.6
Stuart, 1995, USA[35]	Ice hockey	Prospective cohort; one season	Competitors aged 9–14 years in youth hockey (n = 66)	Definition: any event that kept a player out of practice or competition for 24 h or necessitated the attention of a doctor. Measurement: all injuries identified and recorded; no information provided as to who identified injuries; coaches reported exposure time via attendance records	9–10 years, 1.0 (0.1 to 8.9); 11–12 years, 1.8 (0.4 to 9.1); 13–14 years, 4.3 (2.3 to 11.2)
Sutherland, 1976, USA[36]	Ice hockey	Prospective cohort	Competitors aged 5–14 years registered with the National Hockey League	Definition: no clear definition of injury given. Measurement: forms were completed by team coaches and trainers and submitted after each game; interviews with the injured player, coach or manager were necessary to obtain further data	24.9 (19.3 to 32.0)
Timpka, 2002, Sweden[37]	Bandy (similar to ice hockey)	Prospective cohort; one season	Competitors in Swedish South-eastern youth bandy league; rules allow 2 over-age players for each team per game	Definition: all events leading to a cessation of customary participation throughout the day after the injury, or that prevented participation in activities the following day or beyond, any brain concussion, any dental injury requiring professional attention, and any other injury that required professional treatment before return to play; severe, period of absence exceeding 8 days. Measurement: questionnaire eliciting injury information completed by head team coaches directly after each game and forwarded to the regional bandy association office; each team coach and injured player interviewed by a doctor at the end of the season	All injuries: youth 12, 1.5 (0.5 to 5.3); youth 13, 0.4 (0.1 to 2.4); youth 14, 3.2 (1.7 to 6.0); youth 15, 0.8 (0.2 to 2.9). Severe injuries: youth 12, 1.0 (0.2 to 4.1); youth 13, 0; youth 14, 1.8 (0.7 to 4.1); youth 15, 0.4 (0.1 to 2.2)
Willer, 2005, Ontario, Canada[38]	Ice hockey	Prospective cohort; two seasons	Male competitors aged 4–18 years in a youth ice hockey program (n = 2632 (year 1) + n = 2639 (year 2))	Definition: all injuries that results in doctor evaluation and required at least 24 h of restricted activity. Measurement: all injuries reported by team trainer using the Hockey Injury Canada Report form; each form contained a section completed by the treating doctor	Injuries during practice*: 4–7 years, 0.34; 7–8 years, 1.00; 9–10 years, 0.03; 11–12 years, 0.45; 12–13 years, 0.22; 14 years, 0. Injuries during games: 4–7 years, 0.13; 7–8 years, 0.83; 9–10 years, 1.51; 11–12 years, 1.42; 13–14 years, 1.97; 15 years, 1.46

*95% CI could not be calculated.

Table 2 Studies quantifying the risk of activity-related injury in children aged 16 years and under: injuries per other exposure measure

Study (first author, year and location)	Sport/activity	Study design and duration	Participant population	Injury definition and method of measurement	Outcome measure	Results (95% CI)
A: Prospective studies						
Bjorkenheim, 1993, Finland[39]	Ice hockey	Prospective cohort; one season	Competitors aged 9–18 years participating in a junior league (n = 1437)	Definition: any injury that prevented participation in at least one training session or game. Measurement: a questionnaire was completed by all team coaches and players at the end of each season	Injuries per 100 participants	<12 years, 0.9 (0.4 to 1.9); 12–15 years, 12.4 (9.8 to 15.4)
Brust, 1992, Minnesota, USA[40]	Ice hockey	Prospective cohort; one season	Male competitors aged 9–15 years in a community-organised hockey program; results reported for age/weight divisions	Definition: any incident that resulted in a player not being able to continue to participate in a game or practice or that kept a player from participating in physical activities the following day. Measurement: injury forms were collected for each injured player by a number of means: team managers and coaches, players and parents and trained observers; telephone contact was made with a parent of each injured player 1 week after injury	Injuries per 100 player seasons	9–11 years, 70 (54 to 82); 11–13 years, 32 (20 to 47); 13–15 years, 25 (14 to 40)
Goldberg, 1988, New England, USA[41]	American football	Prospective cohort; one season	Competitors aged 8–15 years in Pop Warner Leagues in 71 New England towns (n = 5128). Results extracted for age/weight divisions: jr peewee (8–11 years); peewee (9–12 years); jr midget (10–13 years); midget (11–14 years); jr bantam (12–15 years)	Definition: any incident causing over 7 days of missed activity; moderate, 8–21 days missed; major, >21 days missed. Measurement: coaches were responsible for keeping records of injuries; in addition, players were randomly contacted at end of season	All injuries per 100 player seasons; major injuries per 100 player seasons	All injuries: jr peewee, 1.9 (1.1 to 3.2); peewee, 2.7 (2.0 to 3.6); jr midget, 5.8 (4.7 to 7.1); midget, 8.4 (6.9 to 10.1); jr bantam, 9.6 (6.1 to 14.9). Major injuries: jr peewee, 0.7 (0.3 to 1.7); peewee, 0.9 (0.6 to 1.5); jr midget, 2.4 (1.8 to 3.3); midget, 3.3 (2.4 to 4.4); jr bantam,3.4 (1.6 to 7.2)
Gutgesell, 1991, USA[42]	Basketball	Prospective cohort	Competitors aged 5–12 years competing in a YMCA program (n = 510 (406 boys, 104 girls))	Definition: any injury; significant, unable to play for at least one session. Measurement: observers recorded all injury occurrences during games and practices	Injuries per 100 athlete exposures (games and practices); injuries per 100 participants; significant injuries per 100 participants	Injuries per 100 athlete exposures: 4.86 (3.58 to 6.58). Injuries per 100 participants: boys: 6.16 (4.22 to 8.93); girls: 13.46 (8.22 to 2.14). Significant injuries per 100 participants: 2.35 (1.36 to 4.07)
Kopjar, 1995, Stavanger, Norway[43]	Bicycle riding	Prospective injury surveillance; 4 years	All children in Stavanger aged 10–15 years (n = 7256)	Definition: all bicycle-related injuries treated by Central hospital and emergency clinic. Measurement: bicycle use in population estimated from proportion of children who ride bicycles at least once a week	Per 1000 bicycle rides (to and from school); per 1000 bicycle users (other travel)	Per 1000 bicycle rides: boys: 10–12 years, 2.9 (1.9 to 4.4); 13–15 years, 6.8 (5.1 to 8.9); girls: 10–12 years, 3.3 (2.2 to 5.0); 13–15 years, 2.5 (1.6 to 4.0). Per 1000 bicycle users: boys: 10–12 years, 9.0 (7.1 to 11.5); 13–15 years, 14.6 (12.0 to 17.6); girls: 10–12 years, 6.4 (4.8 to 8.6); 13–15 years, 4.9 (3.5 to 6.8)
Kucera, 2005, North Carolina, USA[44]	Soccer	Prospective cohort; four seasons	Competitors aged 18 years and younger registered with the North Carolina Youth Soccer Association (n = 7000)	Definition: any injury that resulted in a player being removed for part or all of a game and/or miss subsequent practices or games. Measurement: injuries were reported by team coaches by mailing injury cards detailing details of all injuries to the study investigators each week	Injuries per 1000 athlete exposures	U12–14 years, 3.6 (3.1 to 4.1)
Lee, 1996, Edinburgh, Scotland[45]	Rugby	Prospective cohort	Competitors in schoolboy rugby (n = 1705)	Definition: any incident sustained on the field during match or training that prevented player from further participation. Measurement: an adult link-person at each school collected all relevant injury details; each injured player was then contacted directly by study personnel.	Injuries per 100 player seasons	11 years, 1.53 (0.57 to 3.63); 12 years, 4.20 (1.87 to 6.52); 13 years, 4.64 (2.42 to 6.86); 14 years, 6.43 (3.76 to 9.08); 15 years, 8.89 (5.17 to 12.61)
Linder, 1995, USA[46]	American football	Prospective cohort; two seasons	Competitors aged 11–15 years in junior high football (n = 340)	Definition: any sports-related mishap occurring during practice, drills, scrimmages or games resulting in removal from a practice or game and/or missing a subsequent game or practice. Measurement: injuries were recorded by each team coach, and then forwarded to study personnel on a weekly basis	Injuries per 100 player seasons	8 (6.3 to 10.2)

Table 2 Continued

Study (first author, year and location)	Sport/activity	Study design and duration	Participant population	Injury definition and method of measurement	Outcome measure	Results (95% CI)
Radelet, 2002, USA[47]	Baseball, soccer, softball, American football	Prospective cohort; two seasons	Competitors aged 7–13 years in organised community sports (n = 1659)	Definition: any incident requiring on-field evaluation by coaching staff, first aid or that prevented further participation. Measurement: coaches collected data using a survey tool designed for study	Injuries per 100 athlete exposures (including games and practice)	Soccer, 2.1 (1.7 to 2.5); baseball, 1.7 (1.4 to 2.0); football, 1.5 (1.3 to 1.8); softball, 1.0 (0.7 to 1.3)
Roser, 1970, Seattle, USA[48]	American football	Prospective observational cohort; one season	Competitors aged 9–15 years in Seattle Junior Football Program (n = 2079). Results extracted for league divisions: bee (9–11 years); midget (9–11 years); peewee (10–12 years); gil dobie (13–14 years); bantam (up to 15 years)	Definition: any incident causing no participation in either game or practice. Measurement: coaches completed injury questionnaires; parents were contacted for additional information	Injuries per 100 player seasons	Bee, 3.1 (1.8 to 5.7); midget, 2.3 (1.3 to 3.9); peewee, 2.3 (1.4 to 3.8); gil dobie, 1.4 (0.6 to 2.9); bantam, 3.3 (2.4 to 10.7)
Stuart, 2002, USA[49]	American Football	Prospective cohort; one season	Competitors aged 9–13 years registered with community youth football (n = 42 teams)	Definition: any incident that either kept the player out of the remainder of the game or required doctor attention; all concussion, dental, and eye cases were included. Measurement: all injuries were reported by coaches; all injured players were examined by a doctor and details were taken during this examination	Injuries per 1000 player games; injuries per 1000 player plays	Injuries per 1000 player games: 8.47 (6.52 to 11.01). Injuries per 1000 player plays: 0.17 (0.13 to 0.22)
Sullivan, 1980 Oklahoma, USA[50]	Soccer	Prospective cohort; one season	Competitors aged 7–18 years registered with 2 clubs (80 teams) of the Frontier Country Soccer Association (n = 1272)	Definition: any medical problem occurring during games or practice that prevented further participation; major injuries, more than 7 days play or practice missed. Measurement: coaches reported which players had been injured, parents contacted for details; coaches were contacted weekly by study researchers	Per 100 player seasons	<8 years, 0.30 (0.08 to 1.67); 8–9 years, 1.23 (0.50 to 3.13); 10–11 years, 1.40 (0.62 to 3.23); 12–13 years, 5.11 (2.54 to 10.17); 14–15 years, 17.28 (10.62 to 26.98)
Turbeville, 2003, Oklahoma, USA[51]	American football	Prospective cohort; two seasons	Competitors aged 10–15 years participating in middle school football (n = 646)	Definition: any injury that prevented further participation in game or practice or any head injury resulting in impaired consciousness. Measurement: coaches or athletic trainers recorded details of all injuries	Injuries per 1000 games; injuries per 1000 practices	Injuries per 1000 games: 8.8 (6.3 to 12.2). Injuries per 1000 practices 1.0 (0.7 to 1.4)
Yde, 1990, Denmark[52]	Soccer, handball, basketball	Prospective cohort; one season	Competitors aged 6–18 years participating in a Danish sports club (n = 302)	Definition: an incident occurring during match or training in the club causing the player to miss at least one match or one training session. Measurement: all injured players were interviewed by the study investigators who visited the club weekly and registered all injuries	Injuries per 100 player seasons	Soccer: <10 years, 13.8 (7.5 to 24.3); <14 years, 51.2 (36.7 to 65.4). Handball: <10 years, 0; <14 years, 12.5 (4.5 to 31.2). Basketball: <10 years, 0; <14 years, 0
B: Retrospective studies						
Berger-Vachon, 1986, Rhone-Alpes, France[53]	Soccer	Retrospective analysis of insurance claims data; one season	Competitors of all ages in Rhone-Alpes Soccer League	Definition: any incident reported to Rhone-Alpes Soccer Association insurance company. Measurement: all reports including doctor examination	Risk of injury per season; risk of injury per player per match	Risk of injury per season: 10–11 years, 0.6%*; 12–13 years, 0.9%; 14–15 years, 2.2%. Risk of injury per player per match: 10–11 years, 0.23%; 12–13 years, 0.33%; 14–15 years, 0.9%
Gugenheim, 1976, Houston, USA[54]	Baseball	Examination of players for pitching elbow	Pitchers aged 9–13 years in the Little League Metropolitan – Houston area (n = 595)	Definition: any elbow discomfort during pitching career; minor, did not exclude player from game; major, player excluded from game. Measurement: injuries were retrospectively reported by players; each player reporting an injury was examined by a doctor	Risk of elbow injury per lifetime (1–8 years)	Minor, 17% (14 to 20%); major, 1% (0.5 to 2.2%)
Hale, 1961, USA[55]	Baseball	Analysis of insurance reports; 5 years	Little League baseball players aged 8–12 years (n = 771 810)	Definition: any incident requiring medical attention and reported by doctor to insurance company. Measurement: medical reports submitted by doctors to a single insurance company	Injuries per 10000 balls pitched	1.04*
Kujala, 1995, Finland[56]	Soccer, ice hockey, volleyball, judo, karate	Analysis of insurance registry data; 5 years	All competitors in Finland with license from a sporting association (n = 621 691 person years)	Definition: acute sports injuries requiring medical treatment reported to the insurance company. Measurement: analysis of all national sports injury insurance forms	Injuries per 1000 participants per year	Soccer: 25 (24 to 26). Ice hockey: 36 (34 to 38). Volleyball: 12 (9 to 14). Judo: 30 (21 to 41). Karate: 31 (16 to 55)

Table 2 Continued

Study (first author, year and location)	Sport/activity	Study design and duration	Participant population	Injury definition and method of measurement	Outcome measure	Results (95% CI)
Larson, 1976, Eugene, USA[57]	Baseball	Analysis of players; one season	Competitors aged 10–12 years in Eugene Sports Association Little League (n = 120)	Definition: any elbow discomfort during pitching career; minor, did not exclude player from game; major, player excluded from game. Measurement: retrospective reporting by players; each player examined by a doctor	Rate of minor injury per 100 players per lifetime; rate of major injury per 100 players per lifetime	Rate of minor injury per 100 players per lifetime: 20 (14.5 to 29.0). Rate of major injury per 100 players per lifetime: 0
Marshall, 2003, USA[58]	Baseball, T-ball	Analysis of compensated injury claims; 3 years	T-ball (aged 5–8 years) and baseball (aged 7–12 years) competitors participating in Little League Baseball.	Definition: ball-related and facial injuries for which compensation claims were lodged with an insurance company. Measurement: analysis of insurance claims	Ball related injuries per 100 000 player seasons; facial injuries per 100 000 player seasons	Ball related injuries per 100 000 player seasons: T-ball, 2.1 (1.4 to 3.0); baseball, 44.6 (42.4 to 46.9). Facial injuries per 100 000 player seasons: T-ball, 0.07 (0.02 to 0.41); baseball, 4.5 (3.8 to 5.3)
Molsa, 2003, Finland[59]	Ice hockey	Analysis of insurance claims; 1 year	Competitors aged under 20 years participating in club competition (13706 <12 years, 13363 12–14 years)	Definition: upper extremity injuries requiring medical treatment reported to the insurance company. Measurement: analysis of insurance claims	Upper extremity injuries per 1000 player years	<12 years, 1.5 (0.9 to 2.3); 12–14 years, 9.4 (7.9 to 11.2)

*95% CI could not be calculated.

American football, one study). The highest rates of injury per player season were reported for ice hockey for players aged 9–11 years (70 per 100 player seasons)[40] and soccer for players aged 11–14 years (51.2 per 100 player seasons).[52]

Age and gender differences

In general, injury rates increased with age, but this was not always the case. The most notable exceptions were for ice hockey, for which two studies showed a trend toward higher injury rates in younger players.[31 40]

Gender differences were often non-significant, but girls were injured at a higher rate than boys in most studies presenting gender differences for soccer injury.

DISCUSSION

This systematic review found 48 studies that quantified the risk of injury from physical activity in children aged 5–15 years. Thirteen different sports and activities were represented, with soccer the game studied most often.

The magnitude of injury risk varied across sports: the highest injury rate per hours of exposure was reported for ice hockey, and the lowest was for soccer. However, it appeared that injury rates were greatly influenced by the definition of injury used and the age of participating players.

The highest injury rates expressed as injuries per player season were also reported for ice hockey. Direct comparison between injury rates per player seasons may be problematic, however, if the duration of the playing season varies between sports or organisations such that players are exposed to different numbers of games of practice sessions. This information was not provided in all of the studies.

Comparison between sports using a measure not based on hourly exposure is more difficult. However, some authors contend that such exposure measures may be inappropriate.[49] For example, it has been argued that the constant interruptions that characterise a game of American football mean that players are inactive during a significant proportion of game time, rendering a time-based exposure measurement meaningless. Stuart and colleagues[49] therefore expressed injury rates for American football in terms of player plays. A similar approach was adopted by Hale,[55] who expressed injury rates in terms of balls pitched during football, and by Kujala and colleagues,[56] who reported injuries per bicycle riders and bicycle uses.

Although a wide number of different sports were represented by the included studies, the current knowledge of physical activity-related injury risk in young children remains limited. Except for one study which reported cycling injury rates, all the studies were conducted in organised sports. There were no studies that reported injury rates for unorganised, daily activity.

In addition, very few children at the lower end of the age spectrum were included in the studies, with only seven including children aged less than 8 years.[21 29 36 38 47 50 52] The study results indicate that injury incidence increases with age, but the magnitude of injury risk in very young children remains unknown.

Policy implications

The risk of physical activity-related injury must be considered within the context of the substantial benefits that children gain through participation in sports and activities. In general, the overall injury risk may be considered to be quite low compared with the opportunities for improving physical, psychological and mental health that many activities offer.

At some point, however, questions will be asked about sports and activities for which a higher injury risk is consistently demonstrated. Discouraging children from participation in such activities is undesirable. However, anxious parents may not

What is already known on this topic

- Children receive many physical and psychological health benefits from participating in regular physical activity, but these must be weighed against the risk of injury.
- A vast amount of literature exists on the risk of injury in various sports and activities.

What this study adds

- This systematic review provides a concise summary of the literature detailing the risk of activity-related injury per an objective exposure denominator for children aged 5–15 years.
- The review allows comparison between different sports and activities and highlights the methodological shortcomings and current gaps in the literature on this topic.

permit children to participate if they believe their safety is compromised.

Modification of rules for younger players is one approach that has met with previous success in reducing injuries in some sports. Such approaches are being explored for many activities and coupled with improvements in coaching techniques, equipment safety and maintenance of playing fields may improve the safety of childhood sports and activity without reducing the associated enjoyment and health benefits.

CONCLUSION

The risk of injury per exposure time in children aged 15 years and younger has been quantified for a large number of sports and activities; however, direct comparison of injury risk between sports remains difficult because of varying definitions of injury and heterogeneity in study methods. The injury rates per hours of exposure varied between studies and sports by a magnitude of 10 000. Very few studies have ascertained sport-related injury risk for very young children (aged 8 years and younger).

Authors' affiliations

Anneliese B Spinks, Roderick J McClure, School of Medicine, Griffith University, Meadowbrook, Queensland, Australia

Competing interests: None.

REFERENCES

1 **Cole TJ**, Bellizzi MC, Flegal KM, *et al.* Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000;**320**:1240–3.
2 **Nolan T**, Penny M. Epidemiology of non-intentional injuries in an Australian urban region: results from injury surveillance. *J Paediatr Child Health* 1992;**28**:27–35.
3 **Finch C**, Valuri G, Ozanne Smith J. Sport and active recreation injuries in Australia: evidence from emergency department presentations. *Br J Sports Med* 1998;**32**:220–5.
4 **Brudvik C**. Child injuries in Bergen, Norway. *Inj Prev* 2000;**31**:761–7.
5 **Brudvik C**, Hove LM. Childhood fractures in Bergen, Norway: identifying high-risk groups and activities. *J Pediatr Orthop* 2003;**23**:629–34.
6 **Kypri K**, Chalmers DJ, Langley JD, *et al.* Child injury morbidity in New Zealand, 1987–1996. *J Paediatr Child Health* 2001;**37**:227–34.
7 **Agran PF**, Winn D, Anderson C, *et al.* Rates of pediatric and adolescent injuries by year of age. *Pediatrics* 2001;**108**:E45.
8 **Lyons RA**, Delahunty AM, Kraus D, *et al.* Children's fractures: a population based study. *Inj Prev* 1999;**5**:129–32.
9 **de Loes M**. Exposure data. Why are they needed? *Sports Med* 1997;**24**:172–5.
10 **Queensland Health**. Health priorities: the role of physical activity. Public health physical activity background paper. Brisbane: Queensland Department of Health, October 2003.
11 **National Center for Chronic Disease Prevention and Health Promotion**. *Physical activity and health: a report of the Surgeon General.* Atlanta, GA: US Department of Health and Human Services, 1996.
12 **Andren-Sandberg A**, Lindstrand A. Injuries sustained in junior league handball. A prospective study of validity in the registration of sports injuries. *Scand J Soc Med* 1982;**10**:101–4.
13 **Backous DD**, Friedl KE, Smith NJ, *et al.* Soccer injuries and their relation to physical maturity. *Am J Dis Child* 1988;**142**:839–842.
14 **Davidson RM**. Schoolboy rugby injuries. *Med J Aust* 1987;**147**:119–20.
15 **de Loes M**, Goldie I. Incidence rate of injuries during sport activity and physical exercise in a rural Swedish municipality: incidence rates in 17 sports. *Int J Sports Med* 1988;**9**:461–7.
16 **Durie RM**, Munroe AD. A prospective survey of injuries in a New Zealand schoolboy rugby population. *NZ J Sports Med* 2000;**28**:84–90.
17 **Elias SR**. 10-year trend in USA Cup soccer injuries: 1988–1997. *Med Sci Sports Exerc* 2001;**33**:359–67.
18 **Emery CA**, Meeuwisse WH. Risk factors for injury in indoor compared with outdoor adolescent soccer. *Am J Sports Med* 2006;**34**:1636–9.
19 **Emery CA**, Meeuwisse WH. Injury rates, risk factors, and mechanisms of injury in minor hockey. *Am J Sports Med* 2006;**34**:1960–9.
20 **Garraway M**, Macleod D. Epidemiology of rugby football injuries. *Lancet* 1995;**345**:1485–7.
21 **Hoff GL**, Martin TA. Outdoor and indoor soccer: injuries among youth players. *Am J Sports Med* 1986;**14**:231–3.
22 **Inklaar H**, Bol E, Schmikli SL, *et al.* Injuries in male soccer players: team risk analysis. *Int J Sport Med* 1996;**17**:229–34.
23 **Kakavelikas KN**, Vlazakis S, Vlahakis I, *et al.* Soccer injuries in childhood. *Scand J Med Sci Sports* 2003;**13**:175–8.
24 **Le Gall F**, Carling C, Reilly T, *et al.* Incidence of injuries in elite French youth soccer players: a 10-season study. *Am J Sports Med* 2006;**34**:928.
25 **Lindenfeld TN**, Schmitt DJ, Hendy MP, *et al.* Incidence of injury in indoor soccer. *Am J Sports Med* 1994;**22**:364–71.
26 **Maehlum S**, Dahl E, Daljord OA. Frequency of injuries in a youth soccer tournament. *J Sports Med Phys Fitness* 1986;**14**:73–80.
27 **McMahon KA**, Nolan T, Bennett CM, *et al.* Australian Rules football injuries in children and adolescents. *Med J Aust* 1993;**159**:301–6.
28 **Nilsson S**, Roaas A. Soccer injuries in adolescents. *Am J Sports Med* 1978;**6**:358–61.
29 **Pasternack JS**, Veenema KR, Callahan CM. Baseball injuries: a Little League survey. *Pediatr* 1996;**98**:445–8.
30 **Pringle RG**, McNair P, Stanley S. Incidence of sporting injury in New Zealand youths aged 6–15 years. *Br J Sports Med* 1998;**32**:49–52.
31 **Roberts WO**, Brust JD, Leonard B. Youth ice hockey tournament injuries: rates and patters compared to season play. *Med Sci Sports Exerc* 1999;**31**:46–51.
32 **Schmidt-Olsen S**, Bunemann LKH, Lade V, *et al.* Soccer injuries of youth. *Br J Sports Med* 1985;**19**:161–4.
33 **Schmidt-Olsen S**, Jorgensen U, Kaalund S, *et al.* Injuries among young soccer players. *Am J Sports med* 1991;**19**:273–5.
34 **Soderman K**, Adolphson J, Lorentzon R, *et al.* Injuries in adolescent female players in European football: a prospective study over one outdoor soccer season. *Scand J Med Sci Sports* 2001;**11**:299–304.
35 **Stuart MJ**, Smith AM, Nieva JJ, *et al.* Injuries in youth ice hockey: a pilot surveillance strategy. *Mayo Clin Proc* 1995;**70**:350–6.
36 **Sutherland GW**. Fire on ice. *Am J Sports Med*, 1976;*4*, 2264–9.
37 **Timpka T**, Risto O, Lindqvist K. Injuries in competitive youth bandy: an epidemiological study of a league season. *Med Sci Sports Exerc* 2002;**34**:993–7.
38 **Willer B**, Kroetsch B, Darling S, *et al.* Injury rates in house league, select, and representative youth hockey. *Med Sci Sport Exerc* 2005;**37**:1658–63.
39 **Bjorkenheim JM**, Syvahuoko I, Rosenberg PH. Injuries in competitive junior ice-hockey. 1437 players followed for one season. *Acta Orthop Scand* 1993;**64**:459–61.
40 **Brust JD**, Leonard BJ, Pheley A, *et al.* Children's ice hockey injuries. *Am J Dis Child* 1992;**146**:741–7.
41 **Goldberg B**, Rosenthal PP, Robertson LS, *et al.* Injuries in youth football. *Pediatrics* 1988;**81**:255–61.
42 **Gutgesell ME**. Safety of a preadolescent basketball program. *Am J Dis Child* 1991;**145**:1023–5.
43 **Kopjar B**, Wickizer TM. Cycling to school: a significant health risk? *Inj Prev* 1995;**1**:238–41.
44 **Kucera KL**, Marshall SW, Kirkendall DT, *et al.* Injury history as a risk factor for incident injury in youth soccer. *Br J Sports Med* 2005;**39**:462–6.
45 **Lee AJ**, Garraway WM. Epidemiological comparisons of injuries in school and senior club rugby. *Br J Sports Med* 1996;**30**:213–17.
46 **Linder MM**, Townsend DJ, Jones JC, *et al.* Incidence of adolescent injuries in junior high school football and its relationship to sexual maturity. *Clin J Sport Med* 1995;**5**:167–70.
47 **Radelet MA**, Lephart SM, Rubinstein EN, *et al.* Survey of the injury rate for children in community sports. *Pediatrics* 2002;**110**:e28.
48 **Roser LA**, Clawson DK. Football injuries in the very young athlete. *Clin Orthop Relat Res* 1970;**69**:219–23.
49 **Stuart MJ**, Morrey MA, Smith AM, *et al.* Injuries in youth football: a prospective observational cohort analysis among players aged 9 to 13 years. *Mayo Clin Proc* 2002;**77**:317–22.
50 **Sullivan JA**, Gross RH, Grana WA, *et al.* Evaluation of injuries in youth soccer. *Am J Sports Med* 1980;**8**:325–7.

51 **Turbeville SD**, Cowan LD, Asal NR, *et al*. Risk factors for injury in middle school football players. *Am J Sports Med* 2003;**31**:276–81.
52 **Yde J**, Nielsen AB. Sports injuries in adolescents' ball games: soccer, handball and basketball. *Br J Sports Med* 1990;**24**:51–4.
53 **Berger-Vachon C**, Gabard G, Moyen B. Soccer accidents in the French Rhone-Alpes Soccer Association. *Sports Med* 1986;**3**:69–77.
54 **Gugenheim JJ Jr**, Stanley RF, Woods GW, *et al*. Little League survey: the Houston study. *Am J Sports Med* 1976;**4**:189–200.
55 **Hale CJ**. Injuries among 771,810 little league baseball players. *J Sports Med Phys Fitness* 1961;**1**:80–3.
56 **Kujala UM**, Taimela S, Antti-Poika I, *et al*. Acute injuries in soccer, ice hockey, volleyball, basketball, judo, and karate: analysis of national registry data. *Br J Sports Med* 1995;**311**:1465–8.
57 **Larson RL**, Singer KM, Bergstrom R, *et al*. Little League survey: the Eugene study. *Am J Sports Med* 1976;**4**:201–9.
58 **Marshall SW**, Mueller FO, Kirby DP, *et al*. Evaluation of safety balls and faceguards for prevention of injuries in youth baseball. *JAMA* 2003;**289**:568–74.
59 **Molsa J**, Kujala U, Myllynen P, *et al*. Injuries to the upper extremity in ice hockey: analysis of a series of 760 injuries. *Am J Sports Med* 2003;**31**:751–7.

COMMENTARY

The study of the epidemiology of sports injuries in young athletes is still in its infancy: inconsistencies in injury definition and study methods make comparisons between studies difficult. Also, the hours and modalities of exposure to a given sport vary greatly between countries and depend on the level at which a given sport is played. This article goes some way to trying to ''scientificise'' this field, but our knowledge of the risk of injury related to sports in young children is still very incomplete.

Nicola Maffulli
Keele University School of Medicine, Hartshill, UK; osa14@keele.ac.uk